

# Giant Barkhausen jumps in exchange biased bulk nanocomposites sintered from core-shell $\text{Fe}_3\text{O}_4\text{-CoO}$ nanoparticles

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## 1 – Type of samples

- ▶ Magnetite nano particles as produced by polyol route
- ▶ SPS bulk nanostructured particles
- ▶ SPS CoO coated magnetite nPs

## Structural and magnetic characterization

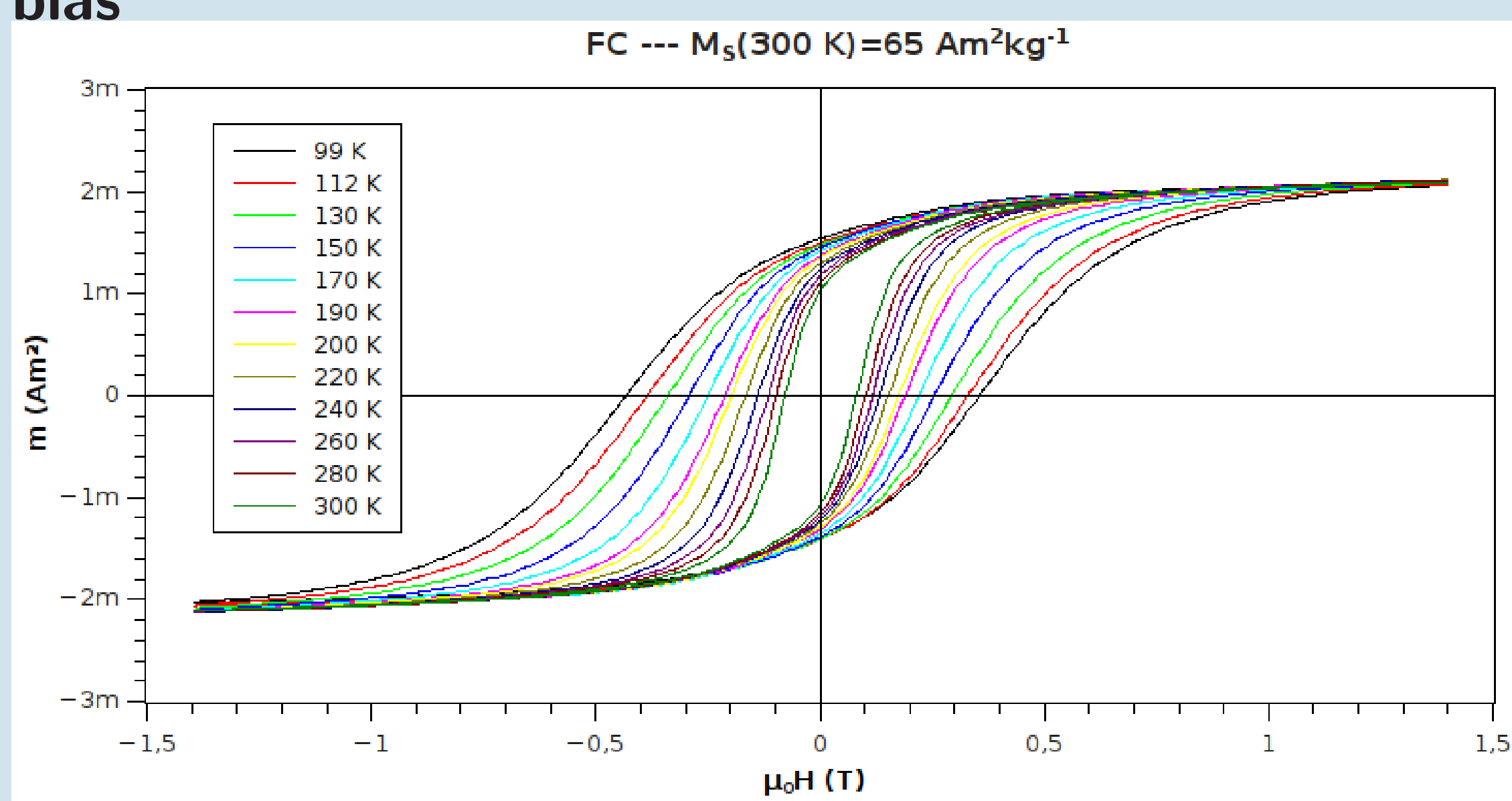
Table: Main structural and microstructural data inferred from MAUD refinement on both powder and ceramic samples.

Sample	Phase	$a$ (pm)	$\langle D_{XRD} \rangle$ (nm)	$\langle \epsilon \rangle$	wt. %
Powder	$\text{FeO}_x$	840.0	17	$4 \times 10^{-3}$	50
	$\text{CoO}_y$	427.0	9	$4 \times 10^{-3}$	50
Ceramic	$\text{FeO}_x$	839.0	100	$4 \times 10^{-5}$	56
	$\text{CoO}_y$	426.5	50	$4 \times 10^{-4}$	37
	fcc-Co	354.0	25	$2 \times 10^{-4}$	7

1. Low field (10 mT) susceptibility measured during cooling + loops @  $T \nearrow$
2. ZFC + loops @  $T \nearrow$
3. FC (1.4 T) + loops @  $T \nearrow$
4. FC below  $T_N$  (260 K) + ZFC + loops @  $T \nearrow$

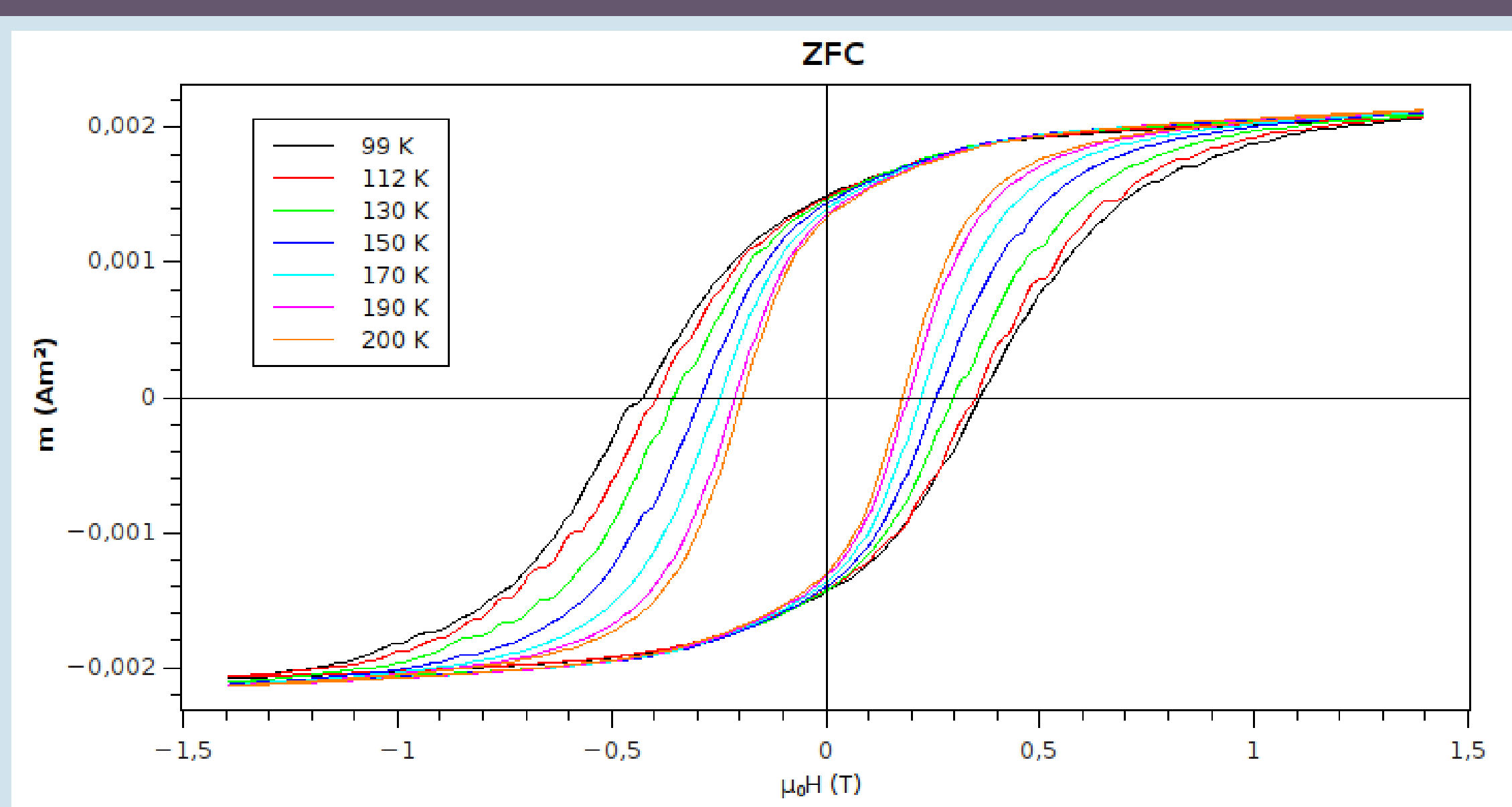
## 3 – CoO/Fe<sub>3</sub>O<sub>4</sub> nanocomposites FC

### Evidence of Antiferromagnetic/ferrimagnetic exchange bias



- ▶ The hysteresis loops are shifted
- ▶ The nanocomposite is much harder than magnetite

## 5 – CoO/Fe<sub>3</sub>O<sub>4</sub> nanocomposites ZFC



## CONCLUSION

### AFM/FiM exchange in CoO/Fe<sub>3</sub>O<sub>4</sub> produces:

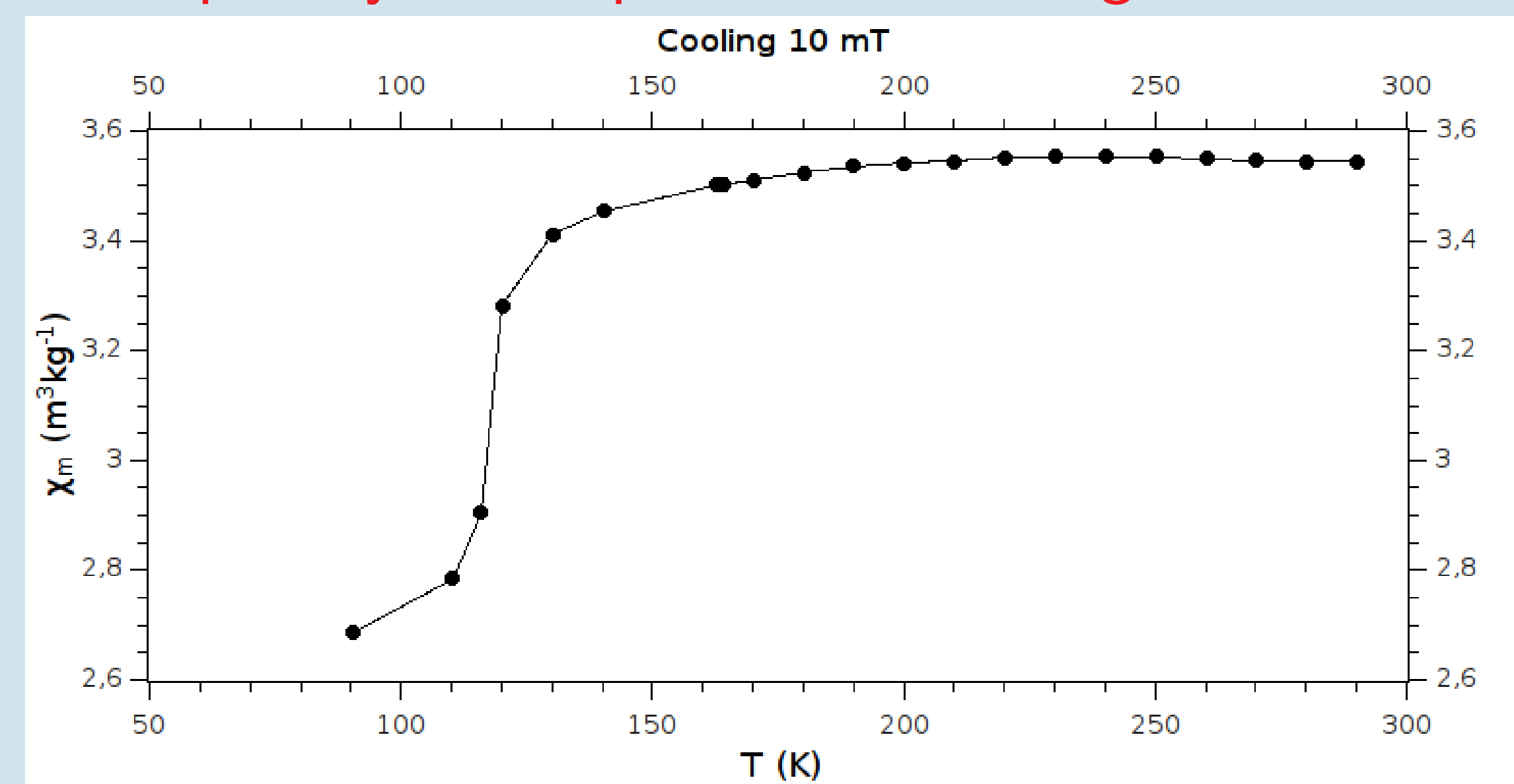
1. a drastic hardening comparable to Ba-hexaferrite
2. hardening remain above  $T_N$
3. shifted loops when field-cooled
4. giant Barkhausen jumps when zero-field-cooled
5. jumps do not appear if the field is switched below 260 K when cooling

### On the origin of anomalous magnetization jumps

- ▶ jumps appear mainly close to Verwey temperature
- ▶ magnetization can be blocked over 80 mT wide steps
- ▶ is the phenomenon field-rate dependent?
- ▶ are the jumps random?

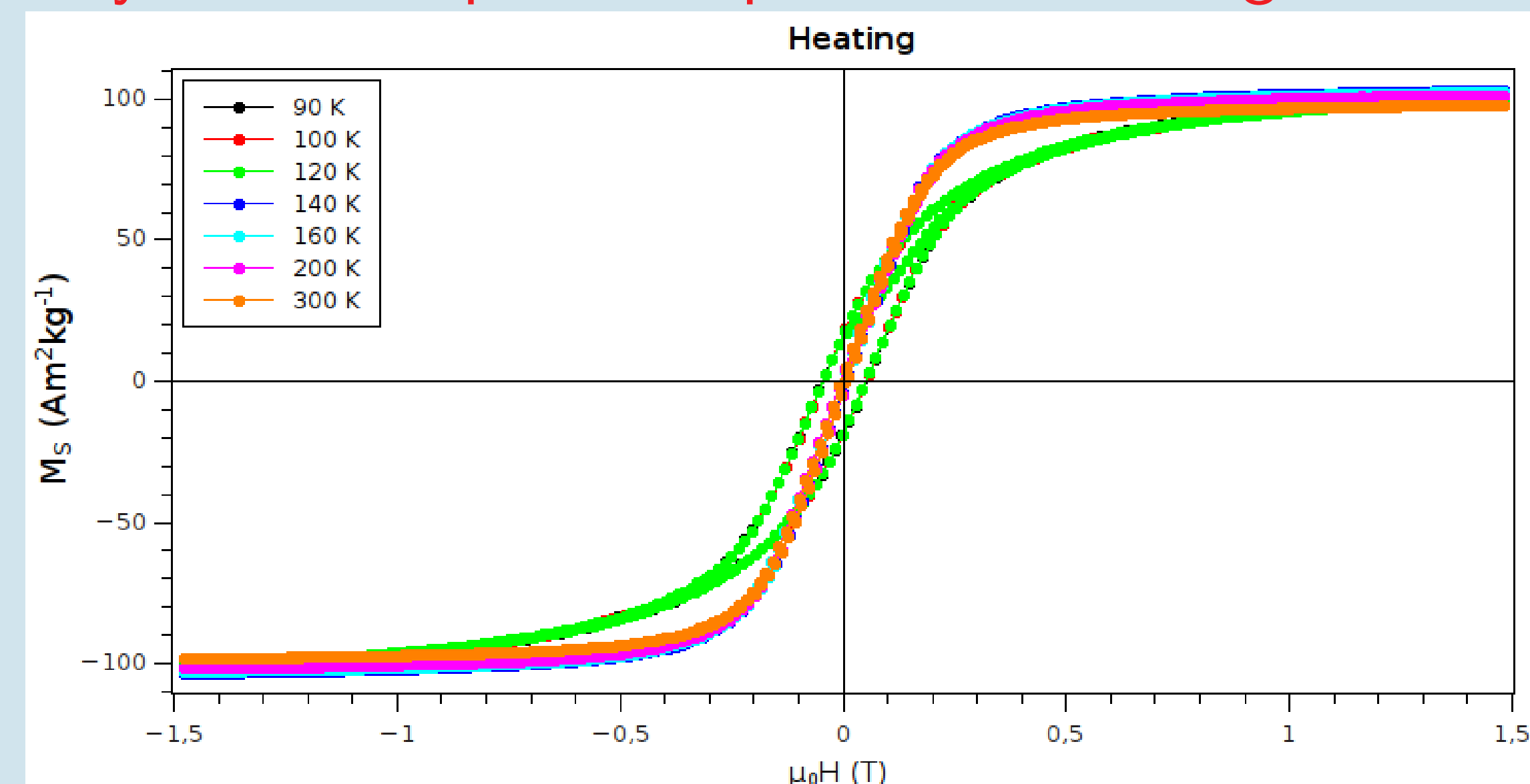
## 2–Spark plasma sintered magnetite

### ▶ Susceptibility vs temperature – cooling



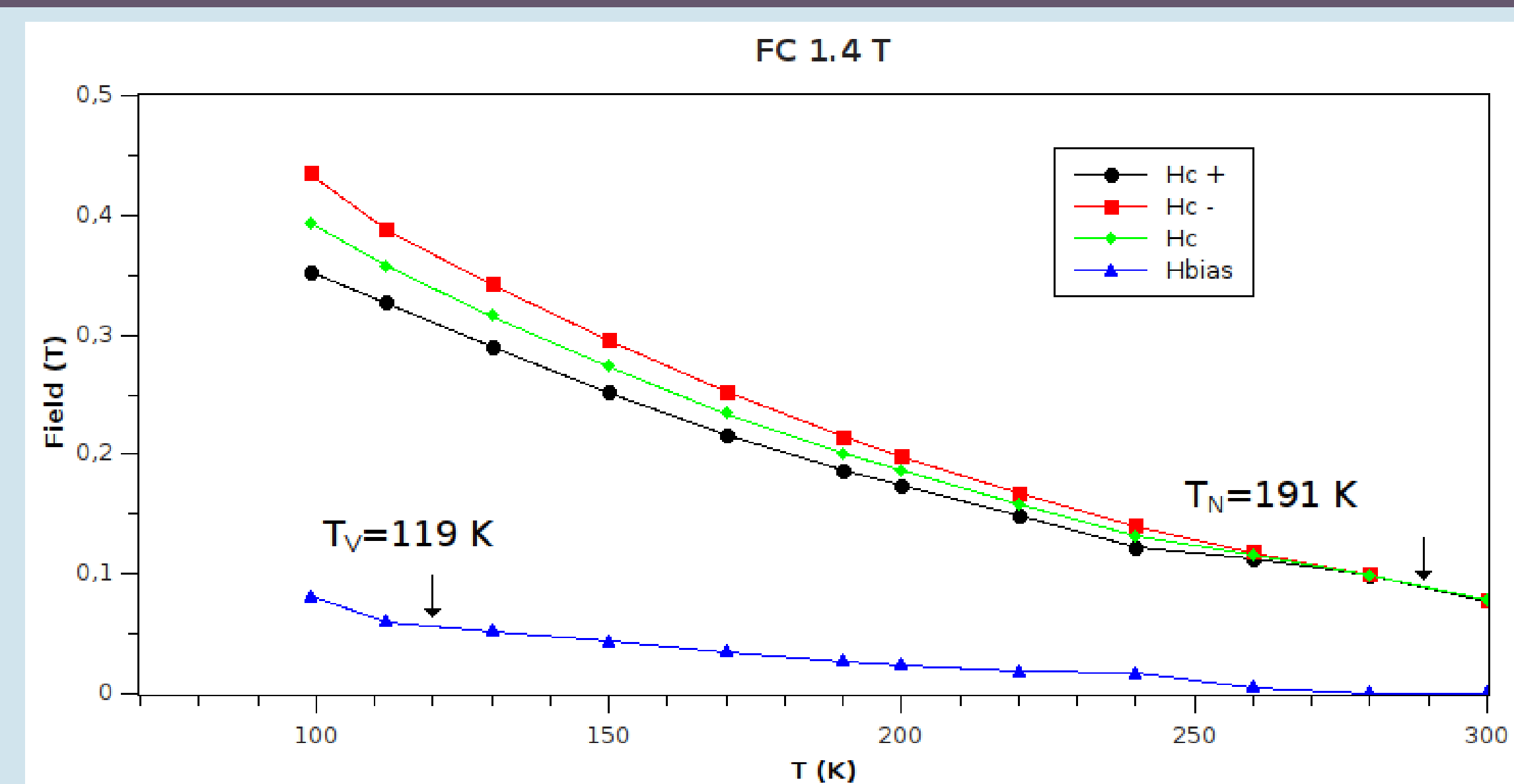
SPS magnetite clearly shows Verwey transition

### ▶ Hysteresis loops vs temperature – heating



Two different type of loops below and above Verwey transition

## 4 – Exchange field and coercivity



- ▶ magnetite is drastically hardened by exchange bias
- ▶  $H_{ex} \searrow 0$  for  $T > T_N$

## 6 – Differential susceptibility

